Notice No.3

Rules for the Manufacture, Testing and Certification of Materials

July 2019

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: June 2020

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Chapter 1, Sections 4, 5 & 6	1 July 2020	NA
Chapter 3, Section 1	1 July 2020	NA
Chapter 3, Section 11 (New Section)	1 July 2020	NA
Chapter 4, Section 1	1 July 2020	NA
Chapter 5, Section 1	1 July 2020	NA
Chapter 6, Section 1	1 July 2020	NA
Chapter 7, Section 1	1 July 2020	NA
Chapter 8, Sections 1 & 2	1 July 2020	NA
Chapter 9, Section 2	1 July 2020	NA
Chapter 10, Section 1	1 July 2020	NA
Chapter 11, Section 1	1 July 2020	NA
Chapter 11, Section 10 (New Section)	1 July 2020	NA
Chapter 12, Section 7 (New Section)	1 July 2020	NA
Chapter 13, Sections 1, 2 & 4	1 July 2020	NA
Chapter 13, Section 10 (New Section)	1 July 2020	NA

Chapter 1
General Requirements

■ *Section 4*
General requirements for manufacture

4.8 Identification of materials

~~4.8.4 Hard stamping is to be used except where this may be detrimental to the material, in which case stencilling, painting or electric etching is to be used. Paints used to identify alloy steels are to be free from lead, copper, zinc or tin, i.e. the dried film is not to contain any of these elements in quantities of more than 250 ppm.~~

4.8.4 Identification and marking is normally made by hard stamping, however, alternative methods may be used by prior agreement. Such methods may be an electronic tagging system such as RFID labels, electric etching, stenciling, or painting. Paints used to identify alloy steels are to be free from lead, copper, zinc or tin, i.e. the dried film is not to contain any of these elements in quantities of more than 250 ppm.

4.8.5 Where alternative methods are to be used, the manufacturer shall have in place a procedure detailing the process and controls for the identification of materials, and control measures for effective traceability of materials.

4.8.6 Hard stamping may, in some cases, be detrimental to the material. Where this concern is identified, an alternative method, such as described in *Ch 1, 4.8 Identification of materials 4.8.4*, shall be used.

~~4.8.5~~ 4.8.7 Where a number of light identical products, ~~items~~, such as ~~shapes~~ sections and bars weighing ≤ 50 kg per meter, are securely fastened together in bundles, the manufacturer need only brand ~~the top item of~~ each bundle. ~~Alternatively, a~~A durable label giving the required particulars may be attached to each bundle.

■ *Section 5*
Non-destructive examination

5.1 General NDE requirements

5.1.5 It is the manufacturer’s responsibility to ensure that all NDE and visual inspections are carried out in a controlled and consistent manner by certified personnel, including the collating of, and provision of accurate reports, which shall be transmitted as appropriate to LR ~~(where applicable),~~ and in ~~any~~ all cases be available upon request to the Surveyor.

5.2 Personnel qualifications

5.2.1 ~~The shipyard, fabricator or manufacturer, is to ensure that~~ ~~personnel~~Personnel carrying out non-destructive examination ~~or~~ and~~–~~interpreting the results of non-destructive examination ~~are~~shall be ~~qualified~~certified to the appropriate level of a nationally recognised scheme. Schemes such as ISO 9712, ~~PCN,~~ ACCP, or SNT-TC-1A~~.~~ fulfil this requirement. Other nationally recognised schemes may be acceptable, and shall be agreed with LR. ~~Level 1 personnel are not permitted to interpret results to Codes or Standards.~~ Furthermore, they shall be certified to the appropriate industry sector for the product type which they are examining.

5.2.2 Level 1 personnel are not permitted to interpret results to Codes or Standards.

~~5.2.2~~ 5.2.3 When certification of personnel is made on an in-house basis under a scheme such as SNT-TC-1A, practical examinations are to be relevant to material, product type, joint configuration, material thickness and acceptance criteria of items inspected for Classification purposes.

Existing paragraph 5.2.3 is to be renumbered 5.2.4.

5.3 Requirements for suppliers of NDE services

5.3.1 The shipyard, fabricator, or manufacturer may have internal NDE services (e.g. internal NDE department), or may acquire external provision of these services from an NDE firm. The NDE provision, whether from internal resource, or external provider, hereinafter shall be known as the supplier.

5.3.2 The supplier carrying out NDE services shall document all controls necessary to ensure that competent and appropriate NDE services can be provided. These include (but are not limited to):

(a) a quality management system covering all necessary and relevant information and processes, enabling effective NDE operations;
(b) training and certification of NDE personnel;
(c) responsibilities of Supervisors and Operators;
(d) equipment;
(e) procedures and work instructions;
(f) control and use of sub-contractors (as applicable); and
(g) reporting.

5.3.3 Documents detailing control of NDE operations and processes shall be available to the Surveyor upon request. These ~~would~~ include items such as:

(a) organisation and management structure, including any subsidiaries;
(b) quality management system;
(c) procedures and work instructions;
(d) details of training requirements, and Written Practice (if applicable) according to SNT-TC-1A;
(e) roles and responsibilities of supervising and practitioner personnel;
(f) company experience;
(g) equipment controls, including guidelines for use of equipment; and
(h) customer feedback, relevant complaints, and any legal proceedings against the company (historical or present); and
(i) any information on other activities which may present a conflict of interest.

5.3.4 The quality management system shall contain details covering, as a minimum, the following items:

(a) Training and certification processes, including visual acuity;
(b) Work procedures and instructions;
(c) Maintenance of documents, records and standards;
(d) Maintenance, control, and calibration of equipment;
(e) Processes for supervision and effective control of operations;
(f) Traceability of records and equipment;
(g) Code of conduct for activities;
(h) Corrective and preventive actions; and
(i) internal and supplier audits (as applicable).

5.3.5 The supplier of NDE services should satisfy the requirements of a Type A or Type B inspection body, as described in ISO/IEC 17020; however, formal certification to ISO/IEC 17020 is not required.

5.3.6 The supplier shall have employed at least one Level III in the organisation, who is deemed a Supervisor, with applicable responsibilities commensurate with this title, and as described in the quality management system and work processes. The Level III Supervisor shall be certified to an externally accredited scheme, i.e. they shall not be appointed under an ‘in-house’ scheme.

5.3.7 The supplier may acquire external provision of independent Level III services to supplement any additional NDE methods which the Level III Supervisor may not be certified for.

Existing sub-Section 5.3 is to be renumbered 5.4.

~~5.4~~ 5.5 Non-destructive examination procedures and work instructions

~~5.4.1~~ 5.5.1 All non-destructive examinations are to be carried out to a procedure that is representative of the item under inspection.

As a minimum the procedures are to be in accordance with the following:

(a) Procedures are to identify the component to be examined, the NDE method, the equipment to be used and the full extent of the examinations including any test restrictions.
(b) Procedures are to specify the qualification and certification requirements of the inspection personnel to be employed.
(c) Procedures are to state the degree of surface preparation required and the methods of preparation to be used before the examinations are made.
(d) Procedures are to state the reference standards for testing and the acceptance criteria to be applied to the results of the inspections.
(e) Procedures are to include the requirement for components to be positively identified and for a datum system or marking system to be applied to ensure repeatability of inspections.
(f) Procedures are to identify any requirements for increasing the extent of applied NDE where defects have been found during spot examination.
(g) Procedures are to identify reporting requirements.
(h) Procedures are to be reviewed by the Surveyor to ensure that they are appropriate for the product type.
(i) Procedures for radiography are to specify the acceptable optical density within the area of interest on the radiograph.
(j) The minimum optical density within the area of interest on a radiograph is to be equal to or greater than 2,0 for gamma ray and 1,8 for X-ray. A maximum density of 4,0 is acceptable.
(k) Procedures are to include the method and requirements for equipment calibrations and functional checks.
(l) Procedures are to be approved by an ~~operator~~Operator or Supervisor qualified to ~~a minimum of~~ Level III in accordance with a recognised ~~standard~~ certification scheme or body. The Level III shall be certified in the method which is relevant to the testing procedure.
(m) The Surveyor will review procedures for compliance with this Section.

Existing paragraphs 5.4.2 and 5.4.3 are to be renumbered 5.5.2 and 5.5.3.

~~5.5~~ 5.6 Non-destructive examination reports

~~5.5.1~~ 5.6.1 NDE reports are to include all information required to identify how the examination was executed and are to include the following information where appropriate:

(a) Date of test.
(b) Name and qualification of ~~operator~~ Operator with signature of the ~~operator~~Operator.
(c) Details of the component identification, description of test location and volume examined.

(d) Heat treatment status, where applicable.
(e) Weld type, procedure and configuration, where applicable.
(f) Surface condition.
(g) Test procedure.
(h) Equipment used
(i) Test results with a map or record of reportable and/or reject indications, giving location, dimensions and nature of indications.
(j) Reference to acceptance criteria and evaluation in accordance to these criteria.
(k) Material type and thickness.
(l) Calibration.

■ *Section 6*
References

(Part only shown)

Table 1.6.1 List of National and International Standards

Rule reference	Standard
Chapter 1 – General Requirements	ISO 9712 ISO/IEC 17020
Chapter 3 – Rolled Steel Plates, Strip, Sections and Bars	JWES2815 ASTM E45 EN 10247 ISO 6892-1
Chapter 12 – Welding Qualifications	ISO 14732 ISO 148-1

Chapter 3
Rolled Steel Plates, Strip, Sections and bars

■ *Section 1*
General requirements

1.12 Identification of materials

1.12.2 Where a number of light similar or identical products, ~~materials~~, such as sections and bars, weighting ≤ 50 kg per meter, are securely fastened together in bundles, the manufacturer may brand only ~~the top piece of~~ each bundle. ~~or, alternatively, a~~A firmly fastened durable label containing the identification may be attached to each bundle.

■ *Section 11*
High strength steel for special marine applications

11.1 Goal-based framework

11.1.1 The purpose of this Section is to present a goal-based approach to the requirements for high strength steel for special marine applications, not covered elsewhere in the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*. Whilst the primary intent of the application of the material listed herein is for pressure vessels/submersible craft intended for human occupancy, use and application of this material for other constructions may be specially considered within the scope of the goal-based framework.

11.1.2 The goals, functional requirements and performance requirements listed herein relate to the manufacture and testing of applicable base materials.

11.1.3 In addition to this goal-based framework, the relevant requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019* are to be complied with to achieve certification. In order to satisfy the goal-based framework in this Chapter, it is also necessary to comply with the applicable Rules related to materials, manufacture, testing, survey and classification.

11.1.4 The list of goals is as follows:

(a) The material shall withstand the applied design loads and integrity requirements for minimising the risk of loss of the structure due to failure.

(b) The material for components, products and systems shall minimise the hazard to persons, assets or environment in any foreseeable operating conditions.

11.1.5 The list of functional requirements (FR) is as follows:

(a) The material shall be manufactured and finished so as to provide assurance that the appropriate quality and mechanical property requirements are achieved.

(b) The material shall be weldable.

(c) The material shall function in a safe and acceptable manner, for compliance with manufacturing and design criteria.

11.1.6 The list of performance requirements (PR) is as follows:

(a) The material shall have the mechanical properties, for Material Class (Special Application), as specified in *Table 3.11.1 Essential mechanical properties for Material Class (Special Application)*, and any other project requirements.

(b) The material shall have the chemical composition, for Material Class (Special Application), as specified in *Table 3.11.2, Chemical composition for Material Class (Special Application)*, and any other project requirements.

(c) The material shall demonstrate the ability to:

  (i) Withstand explosive loading, when applicable.

  (ii) Meet suitable toughness requirements as required by the application and by the specified testing regime.

  (iii) Withstand tensile loads under the specified operating conditions and meet the requirements of a specified testing regime.

  (iv) Be suitably ductile for loads under the specified operating conditions and meet the requirements of a specified testing regime.

(d) Meet specified identification, dimensional and quality requirements.

(e) All material shall be in the quenched and tempered supply condition or be subject to alternative rolling and heat treatment parameters according to the approved manufacturing specification in order to achieve the required mechanical properties.

(f) The weldability of the material shall be confirmed by either an evidence-based regime according to a recognised method, or by a performance-based regime, agreed with LR:

  (i) The maximum carbon equivalent value (CEV), when calculated using UK Defence Standards criteria, shall be 0,64 (for thickness 6–30 mm) and 0,70 (for thickness 30.1–150 mm).

  (ii) The maximum CEV, when calculated using LR Rules, shall be as per the value of H55QT, within *Table 3.10.3 Maximum Ceq, CET and Pcm values*, contained in *Ch 3, 10 High strength steels for welded structures.*

(g) A typical tensile strength value will be in the range of 640-820 N/mm^2.

Table 3.11.1 Essential mechanical properties for Material Class (Special Application)

Material Class (Special Application)	Yield strength (or 0,2% proof strength) (minimum) N/mm^2	Elongation (minimum) %	Charpy value J (minimum)	Charpy test temperature °C	Hardness value (HB)
High Strength Steel – Special Application 1	550	20	80	−80	207–248

Table 3.11.2 Chemical composition for Material Class (Special Application)

Material Class (Special Application)	Material grade chemical composition for product (Note 1)	
	Element	Element (%) by weight
High Strength Steel – Special Application 1	Carbon	≤0,18
	Manganese	0,10–0,40
	Aluminium (Note 2)	0,015–0,060
	Phosphorus (Note 3)	≤0,015
	Sulphur	≤0,008
	Silicon	0,15–0,35
	Nickel	2,25–3,25
	Chromium	1,00–1,80
	Molybdenum	0,2–0,6
	Nitrogen	≤0,012
	Residual elements	Element (%) by weight
	Titanium	≤0,20
	Vanadium	≤0,20
	Copper	≤0,20
	Arsenic	≤0,03
	Antimony	≤0,010
	Lead	≤0,005
	Tin	≤0,02
	Cobalt (Note 4)	≤0,03

Note 1. The listed product percentage by weight values also applies to ladle percentage weight values, with the exception of sulphur, where the maximum percentage weight value is ≤0,006.

Note 2. The steel is to be fully killed, using aluminium fine grain practice, with a minimum aluminium content of 0,015 per cent and greater than twice the per cent nitrogen.

Note 3. Where plates are specified as subject to stress relief, the preferred maximum phosphorus content is 0,010 per cent and is not to exceed 0,012 per cent.

Note 4. Each cast is to be analysed for cobalt. Where the content exceeds 0,030 per cent, instructions are to be obtained from the project authority before release of the product.

11.2 LR accepted solutions for high strength steel for special marine applications

11.2.1 Provision is made in this Section for weldable high strength steels intended for use in special marine applications, which are not covered elsewhere in this Chapter.

11.2.2 An accepted solution for satisfactorily meeting the goal-based framework is specified in sub-Sections *Ch 3, 11.3 General requirements* to *Ch 3, 11.12 Visual and NDE requirements* of this Section.

11.2.3 The application, in entirety, of the prescriptive content in this Section (including any references leading out) is considered to meet the listed goals.

11.2.4 Alternative proposals for meeting the goal-based framework in *Ch 3, 11.1 Goal-based framework* will be specially considered.

11.2.5 The requirements presented herein represent an accepted material solution to meet the requirements of High Strength Steel – Special Application 1, of which Q1(N) grade rolled plate is an example.

11.3 General requirements

11.3.1 In addition to the requirements of this sub-Section, fulfilment of an accepted solution also requires compliance with the relevant Sections of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*, specifically;

- *Ch 1 General Requirements*,
- *Ch 2 Testing Procedures for Metallic Materials* and
- *Ch 3, 1 General requirements,*

regarding approval and manufacture, testing, inspection and general requirements for materials.

11.3.2 Supplied High Strength Steel – Special Application 1plate product is to be in the thickness range 6,00 mm to 150 mm.

11.4 Manufacture and chemical composition

11.4.1 All plate products are to be produced by LR approved steelmaking processes, and any specific requirements for casting type (e.g. ingot casting or continuous casting) shall be specified by the project.

11.4.2 High Strength Steel – Special Application 1has strict chemical composition ranges and limits for feedstock (‘ladle’) and rolled product. These are indicated in *Table 3.11.2 Chemical composition for Material Class (Special Application)*. Each cast is to be analysed using ladle samples. For product analysis, test samples are to be taken from mid-thickness at the top centre portion of each plate, as shown in *Figure 3.11.1 Location of test pieces for mechanical testing, chemical analysis and metallography*.

11.4.3 Carbon equivalent is to be calculated using the following formula, and the results compliant with the values listed in *Table 3.11.3 Carbon equivalent values*:

$$\mathrm{CEV} = \mathrm{C} + \frac{\mathrm{Mn}}{6} + \frac{\mathrm{Ni}}{40} + \frac{\mathrm{Cr}}{5} + \frac{\mathrm{Mo}}{4} + \frac{\mathrm{Si}}{24} + \frac{\mathrm{V}}{15}$$

Note. This CEV formula is only to be used for High Strength Steel – Special Application class steels. Other references to CEV formulae within LR Rules are not applicable to High Strength Steel – Special Application class steels. Similarly, this formula shall not be used to determine CEV for any other steel or product contained in other Rules, Chapters or Sections not related specifically to High Strength Steel – Special Application 1class steel.

Table 3.11.3 Carbon equivalent values

Plate thickness (mm)	Carbon equivalent values	
	Target	Maximum
6–30 mm	0,62	0,64
30,1–150 mm	0,66	0,70

11.5 Heat treatment

11.5.1 High Strength Steel – Special Application 1plates are to be supplied in the quenched and tempered condition. The plates shall be hardened by heating above the upper critical temperature, but not to more than 950°C, followed by water spray quenching. Subsequent quenching shall be in the range 600°C to 675°C. Heat treatment records are to be supplied for each batch. Pickling or flame descaling is not permitted after heat treatment.

11.5.2 Heat treatment, quenching and tempering operations are to be undertaken under controlled conditions. Furnaces are to be thermally monitored (including temperature uniformity) and calibrated to an appropriate International Standard.

11.6 Cleanliness

11.6.1 Plates are to be subject to inclusion content assessment in accordance with ASTM E45 (latest edition) requirements, as outlined in *Table 3.11.4 Cleanliness requirements*.

Table 3.11.4 Cleanliness requirements

Worst field (as per ASTM E45)		Total fields[1,2]
Type[3]	Severity level[3]	B + C + D ≤ 25
B, C, D (according to JK inclusion rating)	≤ 2	
Notes. 1. The presence of any silicate material is not acceptable. 2. Equivalent inclusion types to ASTM E45 may be used, as defined in standard EN 10247 (i.e. EB, EC, ED) 3. Nomenclature relates to inclusion type and severity. Inclusion type and severity level terminology as stated in ASTM E45 (latest edition).		

11.7 Dimensions, flatness, thickness and weight control

11.7.1 Plates are to be supplied to nominal dimensions as required in *Table 3.11.5 Dimensional tolerances*.

Table 3.11.5 Dimensional tolerances

Tolerance on length			
Length of plate		Minus	Plus
Up to and including 3000 mm		0	13 mm
Over 3000 mm up to and including 6000 mm		0	25 mm
Over 6000 mm		0	32 mm
Tolerance on width			
Thickness of plate	**Width**	Minus	Plus
Up to and including 20 mm thick	Up to and including 1800 mm	0	10 mm
	Over 1800 mm	0	13 mm
Over 20 mm thick	Up to and including 1800 mm	0	13 mm
	Over 1800 mm	0	20 mm

11.7.2 Plates are to comply with the flatness tolerances in *Table 3.11.6 Flatness tolerance for plate and measurement information.*

Table 3.11.6 Flatness tolerance for plate and measurement information

Thickness	Flatness tolerance
Less than or equal to 12 mm	10 mm/metre
Greater than 12 mm but less than or equal to 150 mm	6 mm/metre
Method of measurement	(a) If the pitch of waviness is less than 1 m, the measurement should be made by a 1 m straight edge across affected edges. (b) If the pitch of waviness is greater than 1 m, the measurement should be made by a 2 m straight edge across the affected edges.

11.7.3 All plates should be subject to thickness gauging and weight control. Conformance criteria are shown in *Table 3.11.7 Tolerances for thickness and weight control*.

Table 3.11.7 Tolerances for thickness and weight control

Item	Plate thickness (mm)	Tolerances			
		Thickness	Maximum weight		
			Bulk orders		Small orders or individual plates
			Individual plates	Batch	
A	6,1–12	+2% −7%	+2%	+0	+2%
B	12,1–25	+1% −3%	+1%	+0	+1%
C	25,1 and over	+1% −3%	+1%	+0	0
D	Plates for insert pads	+5% -0	Not applicable	Not applicable	Not applicable
Note 1. Thickness gauging is to be undertaken in accordance with specific project requirements. Note 2. Plates are to be weighed after final heat treatment with any surface dressing and abrasive blasting completed. Scale accuracy should be ±1,0 per cent of the nominal weight of subject plate.					

11.8 Surface preparation and priming

11.8.1 All plates shall be abrasively blasted in accordance with specific project requirements.

11.8.2 To avoid flash rusting and surface contamination following abrasive blasting, the steel shall be immediately coated with a prefabrication primer in accordance with the recommendations of the coating manufacturer.

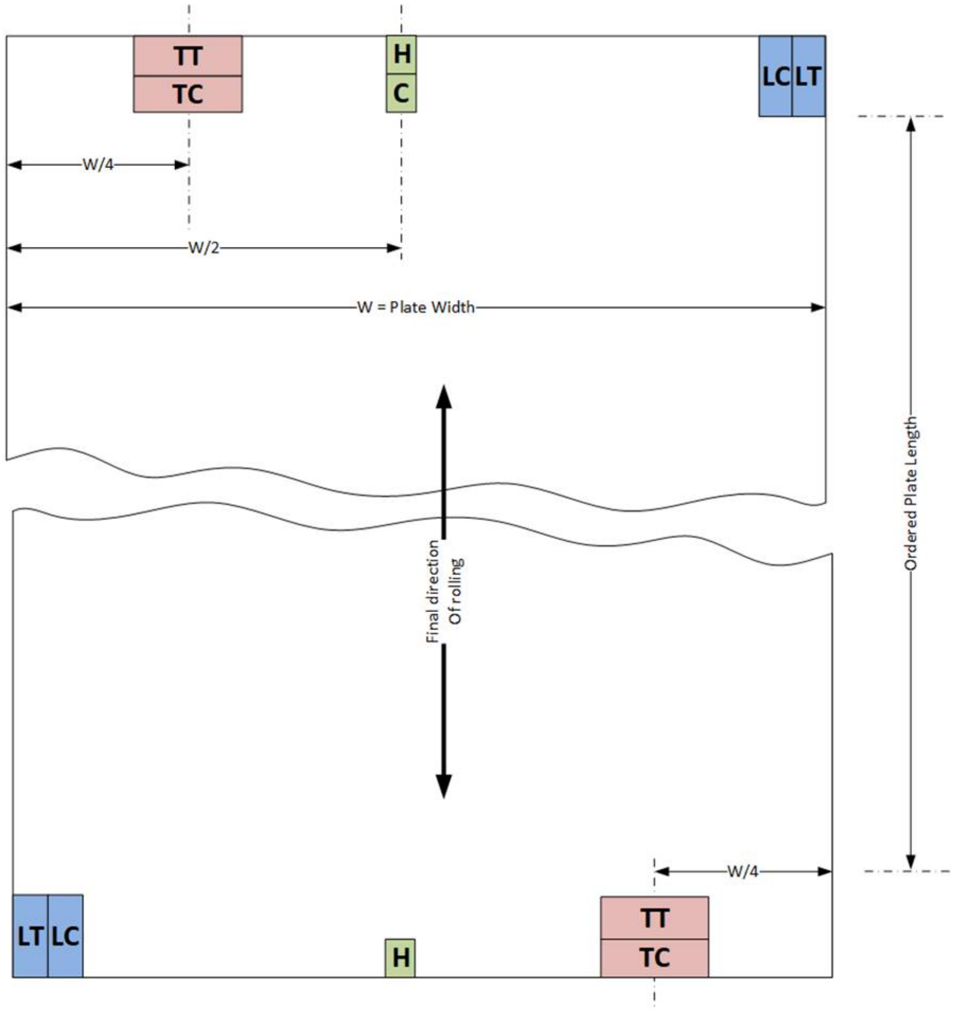
11.8.3 Prefabrication primers shall be of a type specified by the project and approved by LR.

11.9 Mechanical tests

11.9.1 Sampling: Test specimens are to be taken from each finally heat-treated plate in accordance with *Table 3.11.8 Mechanical test samples*. The locations of test samples for mechanical testing, chemical analysis and metallography are indicated in *Figure 3.11.1 Location of test pieces for mechanical testing, chemical analysis and metallography*. When required, through-thickness tensile requirements (sampling, testing and acceptance criteria) are to be defined by the project requirements.

Table 3.11.8 Mechanical test samples

Dimensions	**Samples required**
Plates over 3000 mm in length	Tensile – as per *Figure 3.11.1 Location of test pieces for mechanical testing, chemical analysis and metallography*. Charpy – as per *Figure 3.11.1 Location of test pieces for mechanical testing, chemical analysis and metallography*. Samples acquired from both plate ends. Hardness – test at diagonally opposite corners.
Plates under 3000 mm in length	Tensile – as per *Figure 3.11.1 Location of test pieces for mechanical testing, chemical analysis and metallography*. Charpy – as per *Figure 3.11.1 Location of test pieces for mechanical testing, chemical analysis and metallography*. Samples acquired from one plate end only. Hardness – test at diagonally opposite corners.
Notes: Tensile	(a) Tensile test specimens are to be in accordance with ISO 6892-1: *Metallic materials – Tensile testing – Part 1: Method of test at room temperature*. (b) Test specimens circular in section of 200 mm^2 cross-sectional area are to be taken from the quarter thickness position (providing that plate thickness is sufficient). (c) For plates where 200 mm^2 cross-sectional area test pieces can be taken, but not at quarter thickness position, the axis of the test piece is to be as close as possible to the quarter thickness position. (d) For plates which are too thin for 200 mm^2 cross- sectional area test pieces to be taken, the test pieces are to be the largest possible in accordance with ISO 6892-1. (e) Rectangular section test pieces are to have a gauge length equal to $5{,}65\sqrt{S_0}$ where S_0 is the cross-sectional area of the test piece.
Notes: Charpy	(a) Charpy: Middle line of test specimens is to coincide with mid-plate thickness. (b) Charpy notch to be perpendicular to rolled surface. (c) Charpy specimens to be machined at least 1,0 mm from surface. (d) Standard 10 mm x 10 mm specimens. Sub size specimens permitted for material less than 12 mm thickness (i.e. 10 mm x 5 mm, 10 mm x 7,5 mm).
Notes: Hardness	(a) Test method ISO 6506-1: *Metallic Materials- Brinell hardness test – Part 1: test method* shall be used. (b) If hardness results are outside of specification, batch to be investigated.



Key- at each of the locations indicated on the chart, the following tests should be conducted

LC	3 Off Longitudinal Charpy Impact Test – ½ thickness, orientation L-T
TC	3 Off Transverse Charpy Impact Test – ½ thickness, orientation T-L
LT	1 Off Longitudinal Tensile Test – ¼ thickness
TT	1 Off Transverse Tensile Test – ¼ thickness
H	1 Off Through Thickness Tensile Test, when specified by project requirements / 1 Off Macro
C	1 Off Chemical Analysis

Figure 3.11.1 Location of test pieces for mechanical testing, chemical analysis and metallography

11.9.2 The results of mechanical tests shall comply with the appropriate requirements given in the following tables:

- *Table 3.11.1 Essential mechanical properties for Material Class (Special Application).*
- *Table 3.11.9 Mechanical properties for High Strength Steel – Special Application 1 Class steel.*

Table 3.11.9 Mechanical properties for High Strength Steel – Special Application 1 Class steel

Thickness	**0,2% Proof strength (N/mm^2)**		**Elongation %**	**Reduction in area %**	**Ratio 0,2% proof strength to tensile strength**	**Charpy value J**	**Charpy test temperature °C**	**Hardness HB**
	Min	**Max**	**Min**	**Min**	**Max**			
≤16 mm	550	690	20	-	0,90	80 65 (7,5 x 10 mm sample) 55 (5 mm x 10 mm sample)	(−80) (−80) (−80)	207– 248
16,1 mm up to 150 mm	550	655	20	55 – Longitudinal 50 – Transverse	0,90	80	(−80)	207–248

11.10 Identification of materials

11.10.1 Identification requirements are as follows:

- All plates are to have unique identification to enable full traceability.
- Plates are to be identified according to any project-specific requirements in addition to LR identification requirements.

11.11 Additional approval testing

11.11.1 The project requirements may specify additional testing for manufacturer approval.

11.11.2 The project specification will state the specific dynamic toughness testing procedure, or explosion testing, as applicable.

11.11.3 The project specification will state any additional tests for manufacturer approval, and the performance criteria and properties required.

11.12 Visual and NDE requirements

11.12.1 Visual and non-destructive examination (NDE): Surface inspection and verification of dimensions are the responsibility of the steelmaker and shall be carried out on all material prior to dispatch.

11.12.2 Surface defects: After final heat treatment and abrasive blasting, e.g. shot blasting, each plate is to be examined visually for surface defects. Surface discontinuities shall be defined as imperfections or defects, and will comply with project specific acceptance criteria.

11.12.3 Internal defects: Examination for internal defects shall be carried out as required by the project specification and comply with project-specific acceptance criteria. Where project requirements for examination of plates are not specified, LR requires ultrasonic testing to be carried out and the extent and acceptance criteria shall be agreed with LR.

Chapter 4
Steel Casting

■ *Section 1*
General requirements

1.10 Identification of castings

1.10.1 The manufacturer is to adopt a system of identification, as per the requirements of *Chapter 1, 4.8 Identification of Materials*, which will enable all finished castings to be traced to the original cast, and the Surveyor is to be given full facilities to trace the castings when required.

1.10.3 Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with the Surveyor, noting the general requirements of *Chapter 1, 4.8 Identification of Materials*.

1.10.4 Where a number of light similar or identical products, such as sections and bars, weighting ≤ 50 kg per meter, are securely fastened together in bundles, the manufacturer may brand only each bundle. A firmly fastened durable label containing the identification may be attached to each bundle.

Chapter 5
Steel Forging

■ *Section 1*
General requirements

1.10 Identification

1.10.1 The manufacturer is to adopt a system of identification, as per the requirements of *Chapter 1, 4.8 Identification of Materials*, which will enable all finished forgings to be traced to the original cast, forging process and heat treatment batch, and the Surveyor is to be given full facilities to trace the ~~castings~~ forgings when required.

Chapter 6
Steel Pipes and Tubes

■ *Section 1*
General requirements

1.12 Identification

1.12.2 It is recommended that hard stamping be restricted to the end face, but it may be accepted in other positions in accordance with National Standards and practices and meets the requirements of *Chapter 1,4.8 Identification of Materials*.

1.12.3 Where a number of light products weighting ≤ 50 kg per meter, are securely fastened together in bundles, the manufacturer may brand only each bundle. A firmly fastened durable label containing the identification may be attached to each bundle.

Chapter 7
Iron Castings

■ *Section 1*
General requirements

1.11 Identification of castings

1.11.1 The manufacturer is to adopt a system of identification, as per the requirements of *Chapter 1, 4.8 Identification of Materials*, which will enable all finished castings to be traced to the original cast, and the surveyor is to be given full facilities for tracing the castings, when required.

Chapter 8
Aluminium Alloys

■ Section 1
Plates, bars and sections

1.13.3 Where a number of light products weighting ≤ 50 kg per meter, are securely fastened together in bundles, the manufacturer may brand only each bundle. A firmly fastened durable label containing the identification may be attached to each bundle.

■ *Section 3*
Aluminium alloy castings

3.10 Identification

3.10.1 The manufacturer is to adopt a system of identification as per the requirements of *Chapter 1, 4.8 Identification of Materials,* which will enable all finished castings to be traced to the original cast and the Surveyor is to be given full facilities for tracing the castings when required.

Chapter 9
Copper Alloys

■ *Section 2*
Castings for valves, liners and bushes

2.11 Identification

2.11.1 The manufacturer is to adopt a system of identification as per the requirements of *Chapter 1, 4.8 Identification of Materials*, which will enable all finished castings to be traced to the original cast and the Surveyor is to be given full facilities for tracing the castings when required.

Chapter 10
Equipment for Mooring and Anchoring

■ *Section 1*
Anchors

1.12 Identification

1.12.1 The manufacturer is to adopt a system of identification, as per the requirements of *Chapter 1, 4.8 Identification of Materials,* which will enable all anchor components to be traced to the original cast and the Surveyor is to be given full facilities for tracing the castings when required.

Existing paragraphs 1.12.1 to 1.12.3 are to be renumbered 1.12.2 to 1.12.4.

Chapter 11
Approval of Welding Consumables

■ *Section 1*
General

1.1 Scope

1.1.1 Provision is made in this Chapter for the approval by Lloyd's Register (hereinafter referred to as 'LR') of electrodes, wires, fluxes and other consumables intended for use in the welding of the following types of materials:

(a) Steel of various grades as represented by Grade A through to Grade EH96, *see Ch 11, 3 Electrodes for manual and gravity welding* to *Ch 11, 7 Consumables for use in one-side welding with temporary backing materials*.

(b) A wide range of low-temperature service steels, *see Ch 11, 3 Electrodes for manual and gravity welding* to *Ch 11, 7 Consumables for use in one-side welding with temporary backing materials*.

(c) Stainless steels including nitrogen strengthened grades and some of the duplex varieties, *see Ch 11, 8 Consumables for welding austenitic and duplex stainless steels*.

(d) Aluminium alloys, *see Ch 11, 9 Consumables for welding aluminium alloys.*

(e) High strength steels for special marine applications, *see Ch 11, 10 Consumables for high strength steel for special marine applications.*

1.1.2 For this purpose, welding~~,~~ consumables are categorised and subject to the special requirements of different Sections of this Chapter.

(a) Covered electrodes for manual welding and gravity welding.

(b) Combinations of wire and flux for automatic submerged-arc welding.

(c) Combinations of wire and gas for gas metal-arc welding and wires for self-shielding welding.

(d) Combinations for electro-slag and electro-gas welding.

(e) Combinations with temporary backing materials for one-side welding.

(f) Consumables for welding austenitic and duplex stainless steels.

(g) Combinations for welding aluminium.

(h) Combinations for welding high strength steel for special marine applications.

■ *Section 10*
Consumables for high strength steel for special marine applications

10.1 Goal-based framework

10.1.1 The purpose of this Section is to present a goal-based approach to the requirements for high strength steels for special marine applications, not covered elsewhere in the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*. Whilst the primary intent of the application of the welding consumables listed herein is for pressure vessels/submersible craft intended for human occupancy, use and application of these consumables for other constructions may be specially considered within the scope of the goal-based framework.

10.1.2 The goals, functional requirements and performance requirements listed herein relate to the manufacture and testing of applicable welding consumables.

10.1.3 In addition to this goal-based framework, the relevant requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019* are to be complied with to achieve certification. In order to satisfy the goal-based framework in this Chapter, it is necessary to comply with the other applicable Rules related to materials, manufacture, testing, survey and classification.

10.1.4 The list of goals is as follows:

(a) The welding consumables will be capable of producing weld joints that have the integrity to minimise the risk of loss of the structure due to failure.

(b) The welding consumables and resulting welds shall minimise the hazard to persons, assets or environment in any foreseeable operating conditions.

10.1.5 The list of functional requirements (FR) is as follows:

(a) Welding consumables shall have acceptable chemical and mechanical properties to be suitably matched to the base material properties, to achieve the required weld joint properties and to withstand the applied design loads.

(b) Welding consumables are to be suitable for the welding processes used.

(c) Welding consumables and resulting welds shall be able to function in a safe and acceptable manner, for compliance with manufacturing and design criteria.

10.1.6 The list of performance requirements (PR) is as follows:

(a) The mechanical properties of the weld metal shall comply with the consumable grade requirements stated in *Table 11.10.1 Mechanical property requirements for deposited metal tests (manual, semi-automatic and automatic multi-run techniques) for consumable grade and applicable Material Class (Special Application).*

(b) Results of the weld metal chemical analysis are not to exceed the limit values specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case. The sulphur and phosphorus content of the weld metal is to be controlled so that it is not detrimental to the properties of the weld. The content of each is not to exceed 0,020 per cent.

(c) All welding consumable combinations shall achieve a minimum low hydrogen grade of H5.

(d) The manufacturers plant and method of production shall ensure uniformity in manufacture.

(e) The results of butt weld test assemblies are to comply with the requirements given in *Table 11.10.2 Mechanical property requirements for butt weld tests (all techniques) for consumable grade and applicable Material Class (Special Application)*.

Table 11.10.1 Mechanical property requirements for deposited metal tests (manual, semi-automatic and automatic multi-run techniques), for consumable grade and applicable Material Class (Special Application)

Consumable grade	Material Class (Special Application)	Yield strength N/mm^2 minimum	Tensile strength N/mm^2	Elongation on 50 mm % minimum	Charpy V-notch impact tests	
					Test temperature °C	Individual energy value J minimum
HSS1	High Strength Steel – Special Application 1	550	640–820	18	−50	50

Table 11.10.2 Mechanical property requirements for butt weld tests (all techniques) for consumable grade and applicable material class (Special Application)

Grade	Material Class (Special Application)	Tensile strength N/mm^2	Bend test ratio: D/t	Charpy V-notch impact tests	
				Test temperature °C	Individual energy value J minimum
HSS1	High Strength Steel – Special Application 1	640–820	5	-50	50

10.2 LR accepted solutions for welding consumables for high strength steel for special marine applications

10.2.1 Provision is made in this Section for the welding consumables of high strength steels intended for use in special marine applications, which are not covered elsewhere in this Chapter.

10.2.2 An accepted solution for satisfactorily meeting the goal-based framework is specified in sub-Sections *Ch 11, 10.3 General requirements* to *Ch 11, 10.4 Annual tests* of this Section.

10.2.3 The application, in entirety, of the prescriptive content in this Section (including any references leading out) is considered to meet the listed goals.

10.2.4 Alternative proposals for meeting the goal-based framework in *Ch 11, 10.1 Goal based framework* will be specially considered.

10.2.5 The requirements presented herein represent an accepted solution for LR certified welding consumables, for use with High Strength Steel – Special Application 1 (high strength steel for special applications class 1) of which Q1(N) grade is an example.

10.3 General requirements

10.3.1 In addition to the requirements of this sub-Section, fulfilment of an accepted solution also requires compliance with the relevant Sections of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019,* specifically:

- *Ch 1 General Requirements*,
- *Ch 2 Testing Procedures for Metallic Materials*,
- *Ch 11, 1 General,*
- *Ch 11, 2 Mechanical testing procedures,*

regarding approval and manufacture, testing, inspection and general requirements for welding consumables.

10.3.2 Tests are to be carried out generally in accordance with *Ch 11, 3 Electrodes for manual and gravity welding*, *Ch 11, 4 Wire-flux combinations for submerged-arc automatic welding*, *Ch 11, 5 Wires and wire-gas combinations for manual, semi-automatic and automatic welding* and *Ch 11, 7 Consumables for use in one-side welding with temporary backing materials*, depending upon the type of consumable, except as otherwise detailed in this Section.

10.3.3 All consumables shall be in accordance with recognised Standards and conform to the following requirements.

10.3.4 Dependent on the results of mechanical and other tests, approval will be granted by assigning the grade HSS1.

10.3.5 Steel plate material for test panels is to be the same as the intended application of material class, i.e.High Strength Steel – Special Application 1.

10.3.6 Where the relevant Section requires deposited metal assemblies to be made and tested, the results of all tensile and notch impact tests are to comply with the requirements given in *Table 11.10.1 Mechanical property requirements for deposited metal tests (manual, semi-automatic and automatic multi-run techniques) for consumable grade and applicable Material Class (Special Application)*.

10.3.7 The chemical analysis of the deposited weld metal in each deposited metal test assembly is to be supplied by the manufacturer and is to include the content of all significant alloying elements. The results are to comply with *Ch 11, 10.1 Goal-based framework 10.1.6.(b).*

10.3.8 Test methods to be used for low hydrogen approval are to be in accordance with *Ch 11, 3.4 Hydrogen test*. Results are to meet the requirements of *Ch 11, 10.1 Goal-based framework 10.1.6(c).*

10.3.9 Where the relevant Section requires butt weld assemblies to be made and tested, the results of transverse tensile, notch impact and bend tests are to comply with the requirements given in *Table 11.10.2 Mechanical property requirements for butt weld tests (all techniques) for consumable grade and applicable Material Class (Special Application)*, as appropriate. The position of fracture from the transverse tensile test is to be reported.

10.3.10 Approval of the consumable is limited to use up to a maximum heat input equal to that used during the approval test.

10.4 Annual tests

10.4.1 Annual tests are to be carried out as required by the relevant Section appropriate to the type of consumable and welding technique.

10.4.2 The results are to comply with the requirements given in *Table 11.10.1 Mechanical property requirements for deposited metal tests (manual, semi-automatic and automatic multi-run techniques) for consumable grade and applicable Material Class (Special Application)* and *Table 11.10.2 Mechanical property requirements for butt weld tests (all techniques) for consumable grade and applicable Material Class (Special Application),* as appropriate.

■ *Section 7*
Welding qualification requirements for high strength steel for special marine applications

7.1 Goal-based framework

7.1.1 The purpose of this Section is to present a goal-based approach to the requirements for high strength steels for special marine applications, not covered elsewhere in the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*. Whilst the primary intent of the application of the welding qualifications listed herein is for pressure vessels/submersible craft intended for human occupancy, use and application of these qualifications for other constructions may be specially considered within the scope of the goal-based framework.

7.1.2 The goals, functional requirements and performance requirements listed herein relate to welding qualifications required to be performed for construction.

7.1.3 In addition to this goal-based framework, the relevant requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019* are to be complied with for certification. In order to satisfy the goal-based framework in this Chapter, it is necessary to comply with the other applicable Rules related to materials, manufacture, testing, survey and classification.

7.1.4 The list of goals is as follows:
(a) Welding qualifications shall demonstrate that the resulting weld joints have the integrity to minimise the risk of loss of the structure due to failure.
(b) Welding qualifications shall demonstrate that the resulting welds minimise the hazard to persons, assets or environment in any foreseeable operating conditions.

7.1.5 The list of functional requirements (FR) is as follows:
(a) Welding procedure qualification tests shall demonstrate acceptable chemical and mechanical properties for the application and withstand the applied design loads.
(b) Welds produced in accordance with a qualified weld procedure and by qualified welders shall be able to function in a safe and acceptable manner, for compliance with the manufacturing and design criteria.

7.1.6 The list of performance requirements (PR) is as follows:
(a) For welding procedure qualification tests, the mechanical properties for category A and B welds shall comply with the requirements stated in *Table 12.7.1 Mechanical property acceptance requirements for butt welding in plate (in welds that form part of the pressure hull boundary, and tensile loading under normal submarine operation) for applicable Material Class (Special Application).*
(b) When required by a specific project or specified testing regime, the surface crack extension from flawed bulge explosion (FBE) tests is to be not greater than 50 mm. The presence and location of any laminar flaws are to be reported for special consideration.
(c) When required by a specific project or specified testing regime, four of the five crack tip opening displacement (CTOD) test results must be greater than 0,1 mm. One value may be less than 0,1 mm provided it is greater than 0,07 mm.
(d) For welding procedure qualification tests, the mechanical properties for category C and D welds shall comply with the requirements stated in *Ch 12, 2 Welding procedure qualification tests for steels* except that Charpy impact test minimum energy requirements are to meet the requirements of *Table 12.7.1 Mechanical property acceptance requirements for butt welding in plate (in welds that form part of the pressure hull boundary, and tensile loading under normal submarine operation) for applicable Material Class (Special Application).*
(e) For welder qualification tests, the results from visual inspection and non-destructive examination (NDE) are to be in accordance with *Ch 12, 2.5 Non-destructive examination (NDE) 2.5.5.*
(f) Welders shall demonstrate that they can consistently meet the above requirement.

Table 12.7.1 Mechanical property acceptance requirements for butt welding in plate (in welds that form part of the pressure hull boundary, and tensile loading under normal submarine operation) for applicable Material Class (Special Application)

Material Class (Special Application)	Tensile test		Charpy V-notch impact tests		
	Yield strength (MPa) *See* Note 1	Elongation (%)	Test temperature (°C)	Average absorbed energy (J) *See* Note 2	Average shear fracture (%) *See* Note 3
High Strength Steel – Special Application 1	>550	>18	−50	>50	>45

Note 1. The individual reduction of area and tensile strength values together with weld metal chemical analysis are recorded for information only.

Note 2. No individual value may be less than 40 J.

Note 3. No individual value may be less than 30 per cent.

7.2 LR accepted solutions for welding qualifications for high strength steel for special marine applications

7.2.1 The requirements of this Section relate to the welding qualifications of high strength steels intended for use in special marine applications, which are not covered elsewhere in this Chapter.

7.2.2 An accepted solution for satisfactorily meeting the goal-based framework is specified in sub-Sections *Ch 12, 7.3 General requirements* to *Ch 12, 7.5 Welder qualification* of this Section.

7.2.3 The application, in entirety, of the prescriptive content in this Section (including any references leading out) is considered to meet the listed goals.

7.2.4 Alternative proposals for meeting the goal-based framework in *Ch 12, 7.1 Goal-based framework* will be specially considered.

7.2.5 The requirements presented herein represent an accepted solution for welding qualifications, certified for use High Strength Steel – Special Application 1, and the appropriate consumable grade for the relevant material class. Q1(N) grade steel is an example of an acceptable material, and HSS1 is an example of an acceptable consumable grade.

7.3 General requirements

7.3.1 In addition to the requirements of this sub-Section, fulfilment of an accepted solution also requires compliance with the relevant Sections of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*, specifically:

- *Ch 1 General Requirements,*
- *Ch 2 Testing Procedures for Metallic Materials,*
- *Ch 12, 1 General qualification requirements,*
- *Ch 12, 2 Welding procedure qualification tests for steels* and
- *Ch 12, 5 Welder qualification tests*,

regarding approval and manufacture, testing, inspection and general requirements for welding qualifications.

7.3.2 Unless stated below, qualification of welding procedures is to be in accordance with *Ch 12, 2 Welding procedure qualification tests for steels* and the qualification of welders is to be in accordance with *Ch 12, 5 Welder qualification tests.*

7.4 Welding procedure qualification tests

7.4.1 Welding procedure qualification tests are to be performed to qualify welding for specific categories, as defined by *Table 12.7.2 Weld categories of high strength steel for special marine applications*.

Table 12.7.2 Weld categories of high strength steel for special marine applications

Category	**Description**
A	Weld forms part of the pressure hull boundary and must withstand explosive loading.
B	Weld must withstand tensile loads under normal submarine operation.
C	Welds in frames and frame to pressure hull welds. These welds may experience shock loads but do not form part of the pressure hull boundary (i.e. their failure would not compromise watertight integrity).
D	Welds in secondary structure where none of the above categories apply.

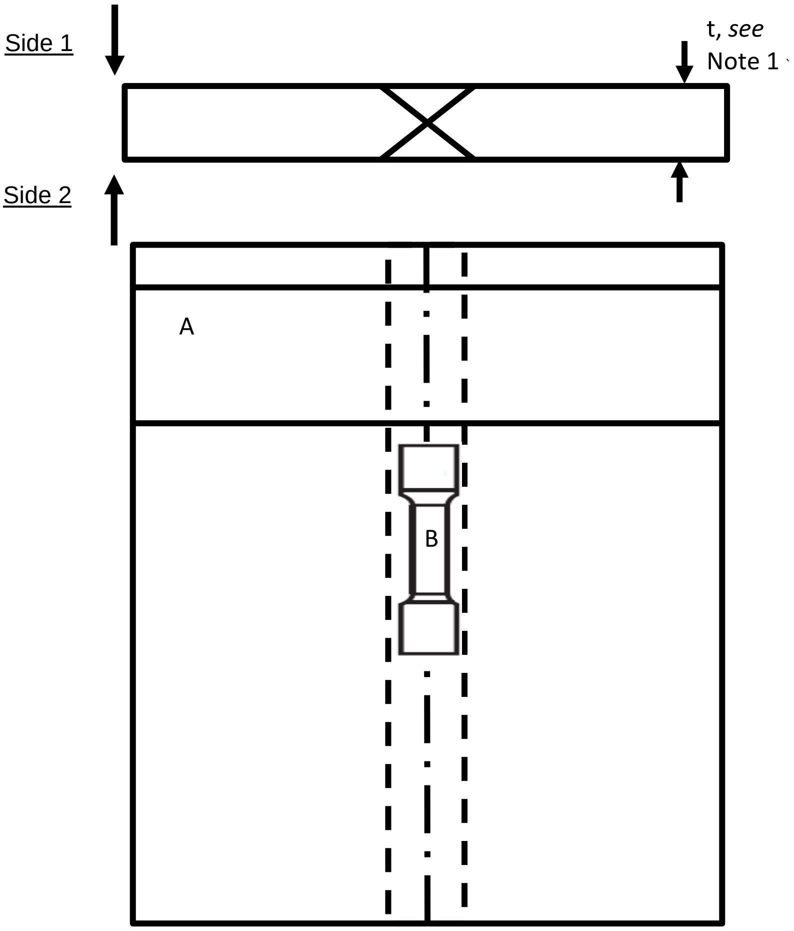
7.4.2 For each weld category the following welding procedure qualification tests are to be completed:

Category A: Test assemblies in accordance with *Ch 12, 7.4 Welding procedure qualification tests 7.4.3*. In accordance with specific project requirements an additional test assembly is to be prepared for FBE testing.

Category B: Test assemblies in accordance with *Ch 12, 7.4 Welding procedure qualification tests 7.4.3*. In accordance with specific project requirements an additional test assembly is to be prepared for Crack Tip Opening Displacement (CTOD) testing.

Category C and D: Two test assemblies from the lowest and highest heat input positions in accordance with *Ch 12, 2 Welding procedure qualification tests for steels* except that Charpy impact test minimum energy requirements are to meet the requirements of *Table 12.7.1 Mechanical property acceptance requirements for butt welding in plate (in welds that form part of the pressure hull boundary, and tensile loading under normal submarine operation) for applicable Material Class (Special Application)*.

7.4.3 A test assembly in accordance with *Figure 12.7.1 Butt welds in plate (category A and B)* is to be prepared and sectioned for mechanical testing. The assembly is to simulate production conditions including minimal restraint and in the worst position. Panels welded in the vertical up position will automatically qualify the procedure for all positions.



Test requirements
A. Charpy, V-notch impact tests.
B. All weld metal tensile test (both sides)

Note 1. For thickness qualification range 20–100 mm, test piece thickness is to be 50 mm. Otherwise for thicknesses below 20 mm the test plate thickness is to be 20 mm. (If outside these thickness ranges, refer to the specific project requirements).

Note 2. The panel length is long enough to leave some archive material for retests. A shorter panel may be used if required.

Note 3. Side 1 is the first side of the test assembly to be welded and side 2 the second side.

Figure 12.7.1 Butt welds in plate (category A and B)

7.4.4 Two sets of Charpy V-notch impact tests are required, notched in the weld centre. One set is to be taken from 2 mm below the surface of side 1 and one set from 2 mm below the surface of side 2.

7.4.5 The Charpy V-notch impact fracture appearance is to be determined in accordance with ISO 148-1: *Metallic materials – Charpy pendulum impact test – Part 1: Test method* or another recognised National Standard.

7.4.6 All weld tensile samples are to be taken from both sides of the weld. The test specimens are to be of a circular cross-section, *see Ch 11, 2.1 Dimensions of test specimens 2.1.1*. Where necessary, reduced size test samples in accordance with ISO 6892-1: *Metallic materials – Tensile testing – Part 1: Method of test room at temperature* or other recognised National Standard are permitted to ensure samples are extracted wholly within the weld metal.

7.4.7 When the procedure is for thin plates, below 20 mm, the Charpy V-notch impact and tensile requirement is to be taken from the mid-section of the weld.

7.4.8 The results of tensile and impact tests for test assembly A are to comply with the performance requirements of *Table 12.7.1 Mechanical property acceptance requirements for butt welding in plate (in welds that form part of the pressure hull boundary, and tensile loading under normal submarine operation) for applicable Material Class (Special Application)*.

7.4.9 When the project requires specifies explosion and/or fracture toughness properties, further test assemblies as per *Figure 12.7.1 Butt welds in plate (category A and B)* are to be welded to facilitate FBE and crack tip opening displacement tests.

7.4.10 FBE tests are to meet the following requirements:

(a) Test specimens are to be notched in the side of the weld exhibiting the highest average crystallinity (i.e. Charpy V-notch impact specimens must be tested and analysed before the FBE can be notched).

(b) Tests are to be carried out at −5°C.

(c) The resulting depth of bulge for the test to be valid must be at least 12,5 mm.

7.4.11 Number of specimens and method of testing for FBE is to be agreed with the project authority.

7.4.12 FBE tests results are to comply with *Ch 12, 7.1 Goal-based framework 7.1.6.(b).*

7.4.13 Two sets of five crack tip opening displacement test specimens are required. One set is to be notched in the first side of the weld and one set notch in the second side of the weld. Both sets of specimens are to be notched in the weld centre. For 20 mm thick test plate the dimensions are to be W = 40 mm, B = 20 mm and the notch is to be through the weld thickness and 20 mm deep. For the 50 mm test plate they are to be no less than 45 mm square with a crack depth to width ratio (a/W) of 0,3. Tests are to comply with *Ch 2, 6 Crack tip opening displacement tests* and tested at −5°C.

7.4.14 Crack tip opening displacement test results are to comply with *Ch 12, 7.1 Goal-based framework 7.1.6.(c).*

7.4.15 For category A and B welds, any change in the following will require a new test piece and requalification:

(a) **Process**: Any change in the process from that used to weld the test plate.

(b) **Edge preparation**:
  - Any change from two-sided welding to full penetration butt welds made from one side only.
  - Any change in the location of the root greater than 2 mm which would bring it to within 15 mm of either plate surface.
  - Any change which results in a single plane fusion line through the thickness when this was not previously (for category 1 only).

(c) **Consumable**:
  - Any change in the wire or electrode used for the root weld of full penetration butt welds made from one side or if the root is located within 15 mm of the plate surface and the root is not removed by back gouging or grinding.
  - Any increase in wire or electrode diameter.

(d) **Parent material**: Any change in plate thickness above or below 20 mm.

(e) **Heat Input**:
  - Any change in heat input beyond the limits used to weld test assemblies.
  - Any increase in the number of welding heads feeding the weld pool.

(f) **Current:** Any change of current or change of polarity.

(g) **Interpass temperature**: Any increase in the permitted interpass temperature.

(h) **Equipment**:
  - Any change in the power source characteristics, i.e. change from constant voltage to constant current or vice versa.
  - Any change in pulse generation for when pulse current is used.
  - Any change to use multiple head welding devices.

7.5 Welder qualification

7.5.1 The test plate thickness is to be no less than 20 mm with the exception that fillet weld test piece is to have a standing test piece of 16 mm, a passing member of equal or greater thickness and a leg length of 11 mm. Mild steel plates may be used in place of high strength steel plates.

7.5.2 Each completed test weld is to be examined and tested in accordance with the requirements of *Table 12.7.3 Welder qualification test requirements for high strength steel for special marine applications*.

Table 12.7.3 Welder qualification test requirements for high strength steel for special marine applications

Examination type	Butt welds	T-butt welds	Fillet welds
Visual	100%	100%	100%
Magnetic particle testing	100%	100%	100%
Radiography	100%	Not required	Not required
Ultrasonic examination	100%	100%	Not required

7.5.3 The results of visual and NDE are to comply with *Ch 12, 7.1 Goal-based framework 7.1.6.(e).*

7.5.4 To retain a qualification, the welder shall have one weld examined using both radiography and ultrasonic examination, every six months.

Chapter 13
Requirements for Welded Construction

■ *Section 1*
General welding requirements

1.11 Non-destructive examination of welds

1.11.1 Non-destructive examinations are to be made in accordance with approved ~~a definitive~~ written procedures ~~prepared and endorsed by a person qualified according to a Nationally Recognised Scheme with a grade equivalent to Level III qualification of ISO 9712, SNT-TC-1A or ASNT Central Certification Program (ACCP). As a minimum, the procedure will identify personnel qualification levels, NDE datum and identification system, extent of testing, methods to be applied with technique sheets, acceptance criteria and reporting requirements. These procedures are to be reviewed by the Surveyor.~~ *See* and shall comply with the general NDE requirements as per *Ch 1, , 5.1General NDE Requirements* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*~~*Ch 1, 5 Non-destructive examination*.~~

1.11.2 Non-destructive examinations are to be undertaken by qualified personnel ~~qualified according to a Nationally Recognised Scheme with a grade equivalent to Level II qualification of ISO 9712, SNT-TC-1A or ASNT Central Certification Program (ACCP). Operators qualified to Level I of the above schemes (or equivalent recognised by LR) may be engaged in testing under the supervision of personnel qualified to Level II or III (or equivalent recognised by LR). Personnel qualifications are to be verified by certification.~~ as per *Ch 1, 5 , 5.1General NDE Requirements* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*

■ *Section 2*
Specific requirements for ship hull structure and machinery

2.12 Non-destructive examination of welds

Table 13.2.7 Acceptance criteria for ultrasonic testing

Echo height	Acceptance criteria for ultrasonic testing, *see* Note
Greater than 100% of DAC curve	Maximum length *t*/2 or 25 mm, whichever is less
Greater than 50% of DAC curve, but less than 100% of DAC curve	Maximum length *t* or 50 mm, whichever is less
~~Indications evaluated to be cracks are unacceptable regardless of echo height;~~ ~~Indications evaluated to be lack of penetration or lack of root fusion in joints welded from one side are unacceptable regardless of echo height.~~	
Indications with an echo height below 33% of DAC curve (DAC minus 10 dB) may be disregarded. Indications with an echo height equal to, or greater than, 33% of DAC curve (DAC minus 10dB) should be evaluated.	
Indications with an amplitude equal to, or greater than, 33% of DAC curve (DAC minus 10dB) evaluated to be cracks are unacceptable regardless of indication length; Indications evaluated to be lack of penetration or lack of root fusion in joints welded from one side are unacceptable if the indications are equal to, or greater than, 33% of DAC curve, and regardless of indication length.	
Note Two adjacent individual discontinuities of length L1 and L2 situated on a line and where the distance L between them is shorter than the shortest discontinuity are to be regarded as a continuous discontinuity of length L1 + L + L2.	

■ *Section 4*
Specific requirements for fusion welded pressure vessels

4.12 Non-Destructive Examination of welds

4.12.1 Non-Destructive Examinations (NDE) of pressure vessel welds are to be carried out in accordance with ~~a nationally recognised code or standard.~~ the general NDE requirements as per *Ch 1, 5.1 General NDE Requirements* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*

4.12.2 NDE is not to be applied until an interval of at least 48 hours has elapsed since the completion of welding
.

~~4.12.3 NDE Personnel are to be qualified to an appropriate level of a nationally recognised certification scheme.~~

~~4.12.4 Qualification schemes are to include assessments of practical ability for Levels I and II individuals. These examinations~~

~~are to be made on representative test pieces containing relevant defects.~~

■ *Section 10*

Requirements for welded construction for high strength steel for special marine applications

10.1 Goal-based framework

10.1.1 The purpose of this Section is to present a goal-based approach to the requirements for high strength steels for special marine applications, not covered elsewhere in the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*. Whilst the primary intent of the application of the requirements for welded construction listed herein is for pressure vessels/submersible craft intended for human occupancy, use and application of this material for other constructions may be specially considered within the scope of the goal-based framework.

10.1.2 The goals, functional requirements and performance requirements listed herein relate to the requirements for fabrication and welding during construction.

10.1.3 In addition to this goal-based framework, the relevant requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019* are to be complied with for certification. In order to satisfy the goal-based framework in this Chapter, it is necessary to comply with the other applicable Rules related to materials, manufacture, testing, survey and classification.

10.1.4 The list of goals is as follows:

(a) The welded constructions shall withstand the applied design loads and have the integrity to minimise the risk of loss of the structure due to failure.
(b) The welded constructions for components, products and systems shall minimise the hazard to persons, assets or environment in any foreseeable operating conditions.

10.1.5 The list of functional requirements (FR) is as follows:

(a) Welded constructions shall be manufactured and finished so as to provide assurance that the appropriate quality and mechanical property requirements are achieved.

10.1.6 The list of performance requirements (PR) is as follows:

(a) Welded constructions shall comply with the specified quality requirements and testing regime.
(b) Weld properties are to consistently meet the following requirements, where batch testing is required by the project:
  (i) average absorbed energy from Charpy V-notch tests shall not be less than 50 J, with no individual value less than 40 J.
  (ii) average crystallinity shall not be less than 55 per cent, with no individual value greater than 70 per cent.
  (iii) the 0,2 per cent proof strength from the all-weld metal tensile test must exceed 550 MPa and the elongation must exceed 18 per cent. Reduction of area and tensile strength values are to be recorded for information only.
  (iv) the above requirements (i), (ii) and (iii) are to be demonstrated on both sides of the weld.

10.2 LR accepted solutions for welded construction for high strength steel for special marine applications

10.2.1 The requirements of this Section relate to the welded construction of high strength steels intended for use in special marine applications, which are not covered elsewhere in this Chapter.

10.2.2 An accepted solution for satisfactorily meeting the goal-based framework is specified in sub-Section *Ch 13, 10.3 General requirements* of this Section.

10.2.3 The application, in entirety, of the prescriptive content in this Section (including any references leading out) is considered to meet the listed goals.

10.2.4 Alternative proposals for meeting the goal-based framework in *Ch 13, 10.1 Goal-based framework* will be specially considered.

10.2.5 The requirements presented herein represent an accepted solution for welded constructions High Strength Steel – Special Application 1and the appropriate consumable grade for the relevant material class. Q1(N) grade steel is an example of an acceptable material, and HSS1 is an example of an acceptable consumable grade.

10.3 General requirements

10.3.1 In addition to the requirements of this sub-Section, fulfilment of an accepted solution also requires compliance with the relevant sections of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*, specifically:

- *Ch 1 General Requirements*,
- *Ch 2 Testing Procedures for Metallic Materials*,
- *Ch 13, 1 General welding requirements* and
- *Ch 13, 2 Specific requirements for ship hull structure and machinery*,

regarding approval and manufacture, testing, inspection and general requirements for welded construction.

10.3.2 Welding and fabrication of High Strength Steel – Special Application 1steel is to be in accordance with *Ch 13, 1 General welding requirements* and *Ch 13, 2 Specific requirements for ship hull structure and machinery* except where outlined below.

10.3.3 Cold forming is not permitted above 250°C and beyond a strain limit of 12 per cent, i.e. mean radius of 4,2 times plate thickness.

10.3.4 All welding is to be performed using the heat input within the range qualified.

10.3.5 Each batch of consumables require testing by the fabricator to demonstrate that tensile and Charpy V-notch impact properties of the weld metal meet the requirements of *Ch 13, 10.1 Goal-based framework 10.1.6.(b)*. The tests shall be carried out on a double-sided weld with a thickness representative of the intended production weld.

10.3.6 As a minimum, visual inspection is to be carried out on the following:

(a) All weld preparations, including excavations for the repair of defects, surfaces to be clad, etc., prior to welding.
(b) Root passes before any subsequent passes are made.
(c) After back gouging.
(d) On completion of the weld on all exposed surfaces of the weld, at the weld toes for evidence of cracking and adjacent to the welds for evidence of damage by stray arcing.
(e) All stops and starts to ensure they are clear of porosity and/or crater cracks.
(f) Any other project specific requirements.

10.3.7 The application of pre-heat is required for all weld joints and is to be in accordance with the qualified welding procedure. It is the responsibility of the fabricator and any project specific requirements to define low or high restraint. The following is recommended:

(a) For root runs a minimum pre-heat of 60°C is required for joints of low restraint and a minimum of 120°C for joints of high restraint.
(b) A minimum pre-heat of 70°C is required for all fill and cap runs.

10.3.8 A higher heat input may be necessary for thicker weld joints.

10.3.9 The application of pre-heat shall be of a uniform soaking type, e.g. using resistance or induction electric heaters. The use of torches to provide preheat is limited to tack or temporary welding locations or to those applications involving welding within a localised area.

10.3.10 The interpass temperature for all multi-pass welds is not to exceed 150°C.

10.3.11 Where stress relieving is considered necessary for a particular application, details of the welding procedure and heat treatment cycle to be applied are to be submitted for special consideration and approval.

10.3.12 Welding of temporary attachments (including lugs, bolts, studs etc.) to pressure hulls and frames is to be kept to a minimum.

10.3.13 Stud welding is to be in accordance with an approved drawing and welding procedure. It is prohibited for shock-mounted equipment, equipment whose failure may result in injury to personnel, or for any equipment inside reactor compartments (where applicable).

10.3.14 For weld joints between High Strength Steel – Special Application 1to other approved structural steels, the welding consumable is to be selected to match the strength of High Strength Steel – Special Application 1. Consumables approved to grade HSS1 are an example of a matching consumable.

10.3.15 Welding conditions and techniques to be employed for production welding is to be in accordance with a welding procedure qualified specifically for joining High Strength Steel – Special Application 1 to the other approved structural steel.

10.3.16 The extent of NDE for all welds will be stated in the project requirements. This is to be considered to be the minimum requirement and the extent is to be increased when warranted by the analysis of previous results.

10.3.17 The results of all NDE is to be evaluated in accordance with these Rules and the project specific requirements.

10.3.18 Weld repair to submersible craft intended for human occupancy already in service is to follow the requirements of these Rules and *Ch 13, 6 Repair of existing ships by welding*.

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